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Cantharellus in southwestern China: a new species and a new record

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Abstract —A new *Cantharellus* species from southwestern China is described, based on morphology and DNA sequencing (LSU rDNA). The new species, *C. vaginatus,* can be distinguished from other chanterelles by the combination of a dark-colored flocculoso-squamulose pileus, a rugulose hymenophore, and thick-walled hyphae in the pileipellis. *Cantharellus appalachiensis*, a species originally described from southeastern North America, is newly reported from China.

Key words — *Basidiomycota*, taxonomy, diversity

Introduction

Cantharellus Adans. ex Fr. (*Cantharellaceae*, *Cantharellales*, *Basidiomycota*), a genus well known for its culinary species, is a core group of the cantharelloid clade, one of the eight major clades in *Homobasidiomycetes* (Pilz et al. 2003; Moncalvo et al. 2006; Hibbett & Thorn 2001). During the past decade, the genus has received much taxonomical attention in temperate and tropical regions and 13 new taxa have been described (Buyck et al. 2000; Eyssartier et al. 2002, 2003, 2009; Ducousso et al. 2004; Henkel et al. 2006; Arora & Dunham 2008; Tibuhwa et al. 2008; Contu et al. 2009; Buyck et al. 2010).

In China, Ying & Zang (1994) and Zang (1996) have enumerated 17 *Cantharellus* names, including two new species originally described from southwestern China: *C. yunnanensis* W.F. Chiu and *C. tuberculosporus* M. Zang (Chiu 1973; Zang 1980). These names include three that apparently should be referred instead to *Gomphus* and *Gerronema* and three now assigned to *Craterellus*, based on recent phylogenetic work re-delimiting the

circumscriptions of *Cantharellus* and *Craterellus* (Dahlman et al. 2000). These taxonomic changes leave only 11 *Cantharellus* species recognized from China.

During our taxonomic investigations of the genus in southwestern China, some noteworthy species representing the diversity of the genus in the region were found in subtropical-tropical forests dominated by *Pinus* spp. and/or *Castanopsis* spp. These species help further our understanding of chanterelle diversity in China and may be of broader biogeographic interest.

Materials & methods

Macroscopic descriptions are based on fresh materials, with color codes based on Kornerup & Wanscher (1961). Micro-morphological features were determined from dried materials examined under a Nikon E400 microscopic (10 × 100). Sections for observing basidia, basidiospores, and pileipellis were made by a razor blade and mounted in 5% KOH solution. Line drawings were made with the aid of a drawing tube (Y-IDT). At least 20 spores were measured from each basidioma; (120/4/3) indicates measurements based on 120 spores from 4 basidiomata in 3 collections. Spore dimensions are given following the form (a–)b–c(–d), with b–c containing at least 90% of all values and the extremes (a, d) enclosed in parentheses. Q indicates the basidiospore length/width ratio, with Q_m denoting the average Q of all spores ± sample standard deviation.

All examined specimens are deposited in the Herbarium of Cryptogams, Kunming Institute of Botany, Chinese Academy of Sciences (KUN-HKAS). The LSU rDNA sequences were submitted to GenBank with accession numbers HM594680, HM594681, HM594682 for *C. vaginatus* and HM582119, HM582120, HM582121 for *C. appalachiensis*.

Taxonomy

Cantharellus vaginatus S.C. Shao, X.F. Tian & P.G. Liu, **sp. nov.** Figs. 1–2

MycoBank MB518730

Pileus atroflocosso-squamulosus. Hymenium tenue rugulosum vel laeve versus marginem. Pileipellis hyphis incrassatis.

Type: China. Yunnan prov., Dehong, caespitose in *Pinus* and *Castanopsis* forest, 14 August 2007, K. Hosaka 07-215 (HKAS 55730, **holotype**).

Etymology: from Latin *vaginatus* (= sheathed), referring to the crust-like covering over the young pileus.

Basidiomata small to medium-sized, thick-fleshed. Pileus 2.0–3.5 cm in diam.; applanate when young, concave and incurved on the margin at maturity; center fleshy, sub-membranous near the margin; surface entirely covered with a blackish incrustation when young, incrustation cracked into adnate squamules when mature, more crowded at center, squamules grayish brown (7F3) or dark brown (7F1); background yellow white (3A2) to light yellow (4A3). Context thick at center, sharply attenuate towards margin, 1–1.5 mm thick halfway to the margin. Hymenophore rugulose, decurrent to one fourth of the length of stipe; veins very ill-defined, becoming more projecting but very spaced near

Fig. 1. Basidiomata of *Cantharellus vaginatus* (holotype).

the pileal margin (<1 mm high); light yellow (3A5–3A4). Stipe 25–35 × 5–8 mm, subcylindrical, equal, solid; surface sub-fibrillose, yellowish white to pale yellow (2A2–3A2). Odor faint, fruity, pleasant.

Basidiospores (Fig. 2a) (120/4/3) 7–9(–9.5) × 5–7(–8) µm [Q = (1.15–) 1.25–1.5(–1.6), Q_m = 1.38 ± 0.08], elliptical to elongate elliptical, colorless, thin-walled. Basidia (Fig. 2b) 55–68 × 7.5–8.5 µm, slender, clavate, with 2–4 sterigmata. Pileipellis (Fig. 2c) a cutis, but more trichoderm-like at the squamules; suprapellis (squamules; Fig. 2d) up to 320 µm thick, composed of thick-walled hyphae, hyphae colorless, interwoven, more erect near surface, rarely inflating to 15 µm; hyphae in sub-pellis interwoven, thin-walled, 3–12 µm in diam. Hymenophoral trama composed of hyphae 4–7 µm in diam., hyphae often inflating towards septa. Stipitipellis a cutis, composed of cylindrical hyphae measuring 5–11 µm in diam., not secondarily septate. Cystidia absent. Clamp connections numerous.

Habit, habitat, & distribution: caespitose, under mixed forest dominated by *Pinus* and *Castanopsis*. Known only from tropical Yunnan, China.

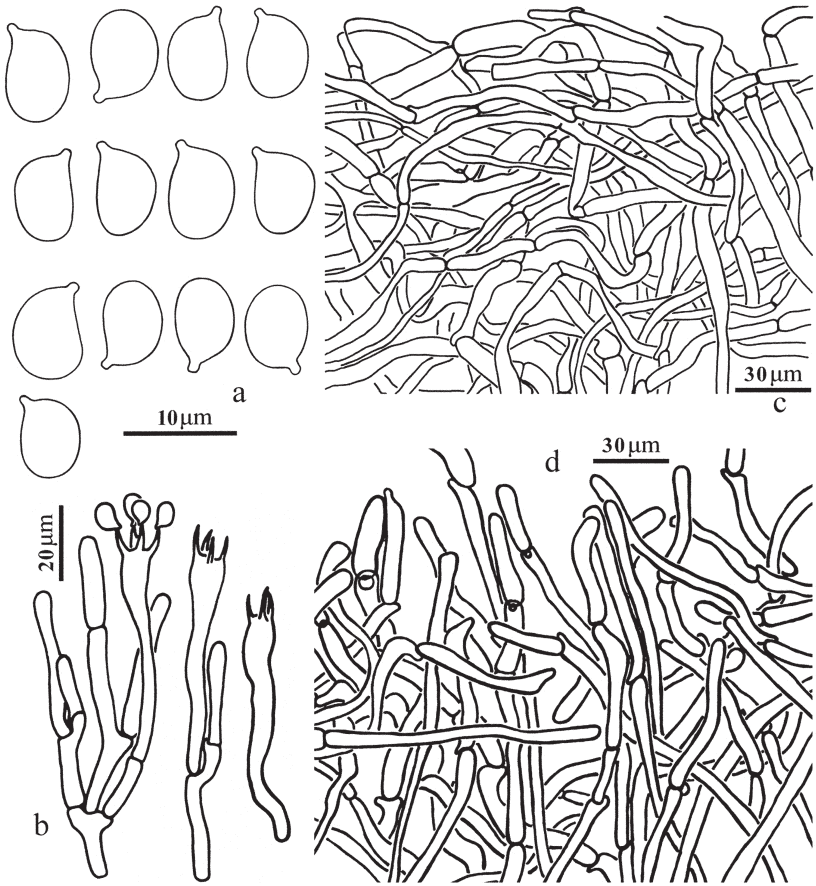

Fig. 2. *Cantharellus vaginatus*.
a. Spores. b. Basidia. c. Pileipellis from an area not covered by squamules.
d. Structure of squamules on pileus.

Additional specimens examined: **China**, **Yunnan**, Dehong, Yingjiang county, alt. 1435 m, 12 August 2007, K. Hosaka 07-193 (HKAS 55728); 14 August 2007, K. Hosaka 07-216 (HKAS 55731).

Notes: In the field, *C. vaginatus* is easily recognized by the fleshy basidiomata, the dark-colored covering on pileus that cracks into squamules at center when mature, and the rugulose hymenophore. The rugulose rather than more sharply ridged hymenophore seems to suggest a *Craterellus* species. The fleshy stipe and obviously elliptical spores, however, are diagnostic of *Cantharellus*. This taxonomic assignment was supported by the LSU rDNA sequence analyses.

Recent taxonomic research has reported several chanterelles with thick-walled hyphae in the pileipellis, including the African *C. tomentosus* (Buyck et al. 2000), Costa Rican *C. atrolilacinus* (Eyssartier et al. 2003), Oceanian *C. garnierii* (Ducousso et al. 2004), Malaysian *C. diminutivus* (Eyssartier et al. 2009), and North American *C. septentrionalis* and *C. tabernensis* (Buyck et al. 2010). In contrast to the sharply ridged hymenophore cited for the above-mentioned species, our new species has a rugulose hymenophore, which becomes gill-like only at the pileal margin. In addition to *C. vaginatus,* the combination of a flocculoso-squamulose pileus and rugulose hymenophore is also found in the European *Cantharellus* species *C. ianthinoxanthus* and *C. ciliatus* (Corner 1966). Compared with *C. vaginatus, C. ianthinoxanthus* is characterized by larger basidiomata (pileus 2.5–10 cm in diam.), a lilaceous tinged hymenophore, and much longer spores (>9 µm) (Corner 1966). The pinkish tinged basidiomata of *C. ciliatus* (Corner 1966) can help to distinguish it from *C. vaginatus*.

Three partial LSU rDNA sequences, varying from 823 bp to 839 bp, were obtained from the three *C. vaginatus* specimens. BLAST in GenBank showed an 100% base pair similarity among the three sequences and a highest similarity (98.8%) with an unnamed sequence of *Cantharellus* collected from India (GU237071). Less similar sequences — labeled *C. cibarius, C. cascadensis,* and *C. subalbidus* — showed a 97% similarity, which supported the phylogenetic position of *C. vaginatus* in *C.* subgen. *Cantharellus* (Corner 1966).

Cantharellus appalachiensis R.H. Petersen, Svensk Bot. Tidskr 65: 402 (1971) Figs. 3–4

Specimens examined: **China**: **Guizhou Prov.**, Suiyang, Kuankuoshui Nature Reserve, 24 July 2010, alt. 1550 m, in fagaceous forest, X.H. Wang 2402 (HKAS 59241); **Yunnan Prov.**, Chuxiong city, market, alt. 1773 m, 7 August 2007, X.F. Tian 6 (HKAS 55811); Dali city, Qili village, 8 August 2008, X.F. Tian 345 (HKAS 55777); Qujing city, market, alt. 2000 m, 14 August 2009, S.C. Shao 46 (HKAS 59093); S.C. Shao 47 (HKAS 59094). **USA**: **North Carolina**, Swain, 8 August 2005, (TENN# 061203); **Tennessee**, Great Smoky Mountains National Park, 22 July 1968, (TENN# 33519, holotype).

Basidiomata (Fig. 3) small, thin-fleshed. Pileus 1.0–2.5 cm in diam., applanate with center depressed, not perforate, margin incurved when young, applanate or slightly reflexed with age, irregularly split at margin, sub-transparently striate; subfleshy to slightly membranous; surface locally dull-grayish due to aggregate minute fibrils, margin duller than light yellow (4A4), center grayish, grayish tinge dominant when young. Context thin, throughout 0.5–1.5 mm thick, fibrous, light yellow (4A3), hygrophanous after bruising. Hymenophore as well-developed gill-like ridges, 1.0–1.5 mm high, 1.0–1.5 mm broad between ridges, decurrent but with a clearly delimitation from the stipe surface, anastomosing due to conspicuous transversal veins in mature basidiomata,

Fig. 3. Basidiomata of *Cantharellus appalachiensis* (HKAS 55811).

light yellow (4A3). Stipe 10–35 mm long, 3–6 mm thick, subcylindrical, tapering downward, irregularly longitudinally furrowed, hollow, darker and more somber than the lamellae. Odor strong, fishy, detectable even when dry. Spore deposit yellowish.

Basidiospores (Fig. 4a) (80/4/4) (6.7–)7–8.5 × 4.5–6 µm (Q =1.24–1.67, Q_m = 1.43 ± 0.08); elliptical to elongate elliptical. Basidia (Fig. 4b) 51–68 × 7–9 µm, clavate, with 4–8 sterigmata. Pileipellis (Fig. 4c) a cutis, composed of interwoven hyphae; hyphae (4–)5–7.5(–11) µm in diam., colorless, thin-walled, not secondarily septate. Hymenophoral trama composed of cylindrical hyphae 3.5–6.5(–10) µm in diam. Stipitipellis a cutis; hyphae 2.5–9 µm in diam., mostly 7 µm in diam. Cystidia absent. Clamp connections common.

Habitat & distribution: solitary or in groups, in mixed forest of *Pinus* and *Rhododendron*, and in fagaceous forest. Known from southwestern China and southeastern America.

Notes: *Cantharellus appalachiensis* was originally described from Great Smoky Mts., Tennessee, and has a rather wide distribution in eastern-southern USA (Petersen & Ryvarden 1971; Buyck et al. 2010). This is the first time that it was

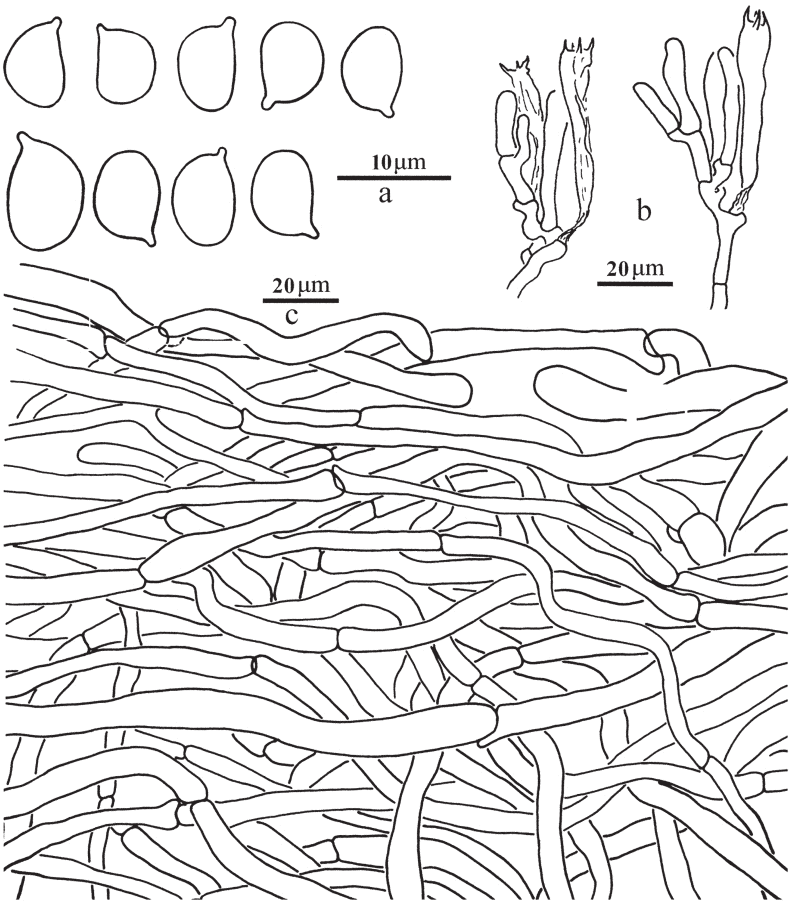

Fig. 4. *Cantharellus appalachiensis*.
a. Spores. b. Basidia. c. Suprapellis of pileus.

found outside America. Petersen and Ryvarden (1971) regarded *C. appalachiensis* related to *C. minor* Peck, now supported by molecular phylogenetic analysis (Moncalvo et al. 2006). The species is characterized by the slender, dull drab-tinged orange basidiomata. The Yunnan collections meet these diagnoses well, except that they have much stronger unpleasant odor. Microscopically, the Chinese collections have broader spores [Q_m = 1.43 vs 1.58 by Petersen & Ryvarden (1971)] and stouter basidia measuring 51–68 × 7–9 μm. Buyck et al. (2010) illustrated very productive basidia for *C. appalachiensis*, which are also very common in our Chinese collections.

Since former work has demonstrated that LSU rDNA can be used as a useful marker at specific level in *Cantharellus* and *Craterellus* (Feibelman et al. 1997), three LSU rDNA sequences from the Chinese collections (HM582119, HM582120, and HM582121) were compared with one sequence originated from the type locality (DQ898690, Moncalvo et al. 2006). All of the sequences are identical, which supports the high morphological similarity between Chinese and American materials.

With the Chinese materials reported here, this species now exhibits a geographic disjunct distribution: southeastern North America—eastern Asia. Up to now, on both continents, the species appear restricted to subtropical montane forests but are quite common within that range. There are very few reports documenting the host of the species. Buyck et al. (2010) reported material from "oak-pine woods" from Texas, USA. In southwestern China, the material was confirmed to be associated at least with fagaceous trees. It is not clear whether such distribution pattern was influenced by the presence of their hosts. Before this work, two other *Cantharellus* species reported with the same geographic distribution were *C. minor* and *C. subalbidus* (Jones et al. 1994, Hyun et al. 1998, Lee et al. 2006). As has been demonstrated by botanists and mycologists (Wu et al. 2000), these southeastern North America and eastern Asia macrofungal disjunctions are of special biogeographical interest and are expected to have individual histories. Whether each of these chanterelles has its own history may need to be tested with faster evolving gene(s) and extensive sampling on both continents (Mueller et al. 2001).

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